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(54) Photo-solidified object having unsolidified liquid ejecting ports and method of fabricating the same.

(57) A superficial model with an inner reinforcing structure having communication ports formed for communication among cells defined by ribs constructing a honeycomb structure. For this purpose, a process of temporarily stopping light exposure is added in a light exposure process for modeling ribs. Alternatively, a process of offsetting phases of ribs is added in the light exposure process for modeling ribs.

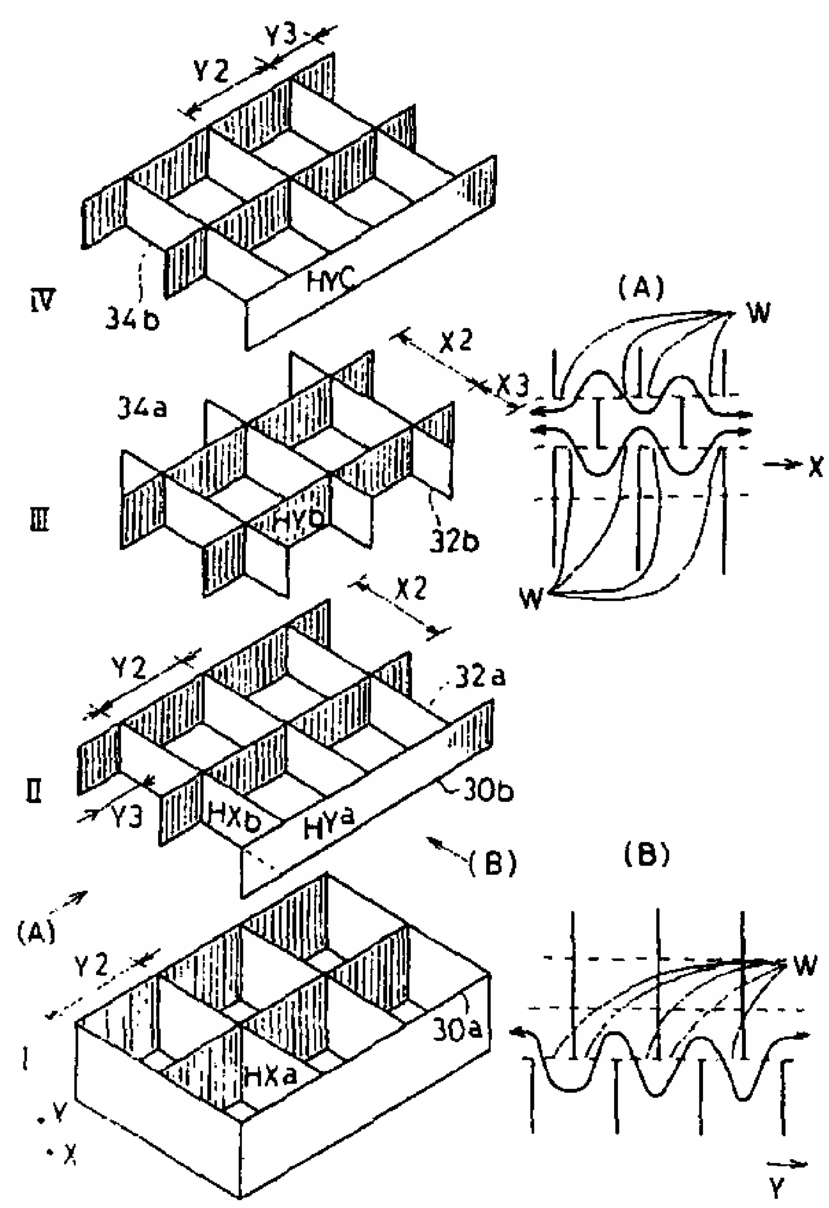

FIG.6

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serve as communication ports for communicating with the cells. According to the photo-solidification modeling method of another aspect of the invention, during stacking of layers of ribs, their phases are offset so as to create a clearance between the ribs which permits communication among the cells.

The present invention will be more fully understood from the following detailed description and appended claims when taken with the accompanied drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows an example of a honeycomb structure according to a first embodiment of the present invention;
FIG. 2 shows an example of a solidified object according to the first embodiment;
FIG. 3 is a flow chart of a modeling procedure according to the first embodiment;
FIG. 4 shows a system construction of a photo-solidification modeling system according to the first embodiment;
FIG. 5 shows another example of the honeycomb structure according to the first embodiment;
FIG. 6 shows an example of the honeycomb structure according to a second embodiment of the present invention;
FIG. 7 shows another example of the honeycomb structure according to the second embodiment;
FIG. 8 are plan views of the honeycomb structures in FIGS. 1, 6 and 7;
FIG. 9 shows an example of the honeycomb structure according to a third embodiment of the present invention;
FIG. 10 is a detailed view of the honeycomb structure in FIG. 9; and
FIG. 11 shows an example of the honeycomb structure in accordance with a fourth embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Now, several embodiments of the present invention will be described.

First Embodiment (honeycomb structure of the type in which some of ribs are eliminated)

In this embodiment, some of ribs constructing an inner honeycomb structure are not formed, or light exposure of some of ribs is eliminated. FIG. 2 shows an example of a photo-solidified object M which has a three-dimensional shape positioned in a three-dimensional space defined by X, Y and Z axes having an outer surface shown by a closed curved surface S and a honeycomb structure formed in a space enclosed by the outer surface. In the drawing, YR designates a region in which the honeycomb structure is composed of ribs extending only in the Y direction, XR a region in which the honeycomb structure is composed of ribs extending only in the X direction, and XYR a region in which the honeycomb structure is composed of ribs extending in the X and Y directions.

FIG. 1 shows a part of the honeycomb structure in an enlarged scale, and the similar structure extends in the X, Y and Z directions. Though the regions XYR, YR and XR are shown separately for better understanding, it should be noted that they are actually continuous.

In the region XYR, ribs HX extending in the X direction and ribs HY extending in the Y direction are formed to fabricate a lattice honeycomb structure. In the region YR, the ribs HX in the X direction are eliminated and only the ribs HY in the Y direction are formed, while in the region XR, the ribs HY in the Y direction are eliminated and only the ribs HX in the X direction are formed.

In the region XYR, the ribs HX and HY arranged in a lattice define a plurality of cells C1, C2 ..., each of the cells being separated from one another. In the region YR, however, as the ribs HX in the X direction are eliminated, the cells C1, C3 and C5 are communicated with one another, and similarly the cells C2, C4 and C6 are communicated with one another. More specifically, the cells C1 and C3 are communicated with each other through a communication port WA, and the cells C2 and C4 are communicated with each other through a communication port WB. Similar communication ports are provided between the cells C3 and C5 and between the cells C4 and C6.

In the region XR, as the ribs HY in the Y direction are eliminated, the cell group composed of C1, C3 and C5 communicating with one another in the region YR communicates with the other cell group composed of C2, C4 and C6 communicating with one another in the region YR. Specifically, the cell group C1, C3 and C5 communicates with the other cell group C2, C4 and C6 through communication ports WC. Consequently, all of the cells C1, C2 ... C6 communicate with one another through the communication ports WA, WB, WC and others.

Also in the upper XYR region, the ribs HX and HY are formed in a lattice, defining cells C7 to C12. Communication between the cells C7 and C8, between the cells C9 and C10 and between the cells C11 and C12 is assured by the corresponding communication ports WC in the region XR, and further, the cell group C7 and C8 communicates with the cell group C9 and C10 through the communication ports WA and WB in the region YR. Thus, all of the cells C1 to C12 communicate with one another.

The communication ports WA, WB, WC and others are designed to have a dimension of more than 1 mm at the shortest side thereof so as to assure suf-

II and III, the Y direction ribs HYa and HYb are offset from each other by 1/2 pitch. Further in regions III and IV, the Y direction ribs HYb and HYc are offset from each other by 1/2 pitch. Thus, this embodiment is characterized in that the pitch of the ribs is offset between adjacent regions. Though the quantity of offset is determined to be 1/2 pitch (i.e. Y2 = 2 x Y3, X2 = 2 x X3), it may be 1/3 pitch or 1/4 pitch. It should be noted that the ribs, in this embodiment, are offset either in the X direction or in the Y direction between adjacent regions, so that the ribs in the direction in which the ribs are not offset are vertically continuous. For example, the ribs 30a and 30b are continuous, and the ribs 32a and 32b are continuous, and similarly the ribs 34a and 34b are continuous, resulting in firm connection of the ribs in adjacent regions and consequently provision of a strong inner honeycomb structure.

With the phases offset in this way, the cells can communicate with one another in the X, Y and Z directions. FIG. 6(A) is a view of the honeycomb structure having the regions I, II, III and IV sequentially stacked in layers as seen in the Y direction, and it will be understood that there is communication in the X direction through communication ports W. FIG. 6(B) is a view of the same as seen in the X direction, and it is also understood that there is communication in the Y direction through the communication ports W.

FIG. 7 shows another example of the second embodiment, in which the phases of the ribs are respectively offset by Y4, X4, -Y4 and -X4 in the sequential regions, so that the honeycomb structure of the region V may be of the same pattern as that of the region IX. In this example, the common pattern of the regions V and IX is preferably used in the XYR region in FIG. 2. Such an arrangement in which three phase-offset regions are provided between the two regions V and IX of the basic pattern permits usage of a common basic pattern and consequently remarkable simplification of software for offsetting the phases.

FIG. 8 includes plan views of the ribs of the honeycomb structures in FIGS. 1, 6 and 7, showing that, in every case, the cells communicate with one another in both of the X and Y directions. In the drawing, respective marks ○, Δ and X show vertically continuous ribs. As shown in FIG. 8 (6), offsetting of the phases by 1/2 pitch in one of the X and Y directions between adjacent regions provides a strong honeycomb structure. FIG. 8(8) shows an example in which the phases are offset in both of X and Y directions in each of the regions. It is apparent that, in this example, the cells can also communicate with one another in both of the X and Y directions. In this case, however, as the upper and lower ribs are point-connected, this structure is applicable to a model which requires a relatively low strength.

Third Embodiment (the honeycomb structure of the type in which each rib is split in the plane thereof)

This embodiment is of the type in which each of the ribs constructing the honeycomb structure is split in the plane thereof. In the first and second embodiments, ribs H are spaced at a certain pitch, but they extend uniformly in the planes thereof and are spaced from one another in the direction perpendicular to the corresponding planes. On the contrary, the third embodiment is characterized in that each rib H is split in the plane thereof.

FIGS. 9 and 10 show an example of such a honeycomb structure, and as shown clearly in FIG. 10, the rib HX extending in a plane perpendicular to the X axis is split into rib sections HX1 and HX2 with a space PX left therebetween. Similarly, the rib HY perpendicular to the Y axis and the rib HZ perpendicular to the Z axis are split in the respective planes at a space. A honeycomb structure fabricated by these ribs is schematically shown in FIG. 9, which has communication ports W formed in each surface of the cubic lattice. It will be more clearly understood when referring to the rib sections HZ1, HZ2, HZ3 and HZ4 perpendicular to the Z axis in FIG. 10. The rib sections HZ1 and HZ2 are separated in a plane perpendicular to the Z axis at a space PZ2. The rib sections HZ3 and HZ4 are separated at a space PZ1. Therefore, a communicating port W of PZ1 x PZ2 is formed in the plane perpendicular to the Z axis.

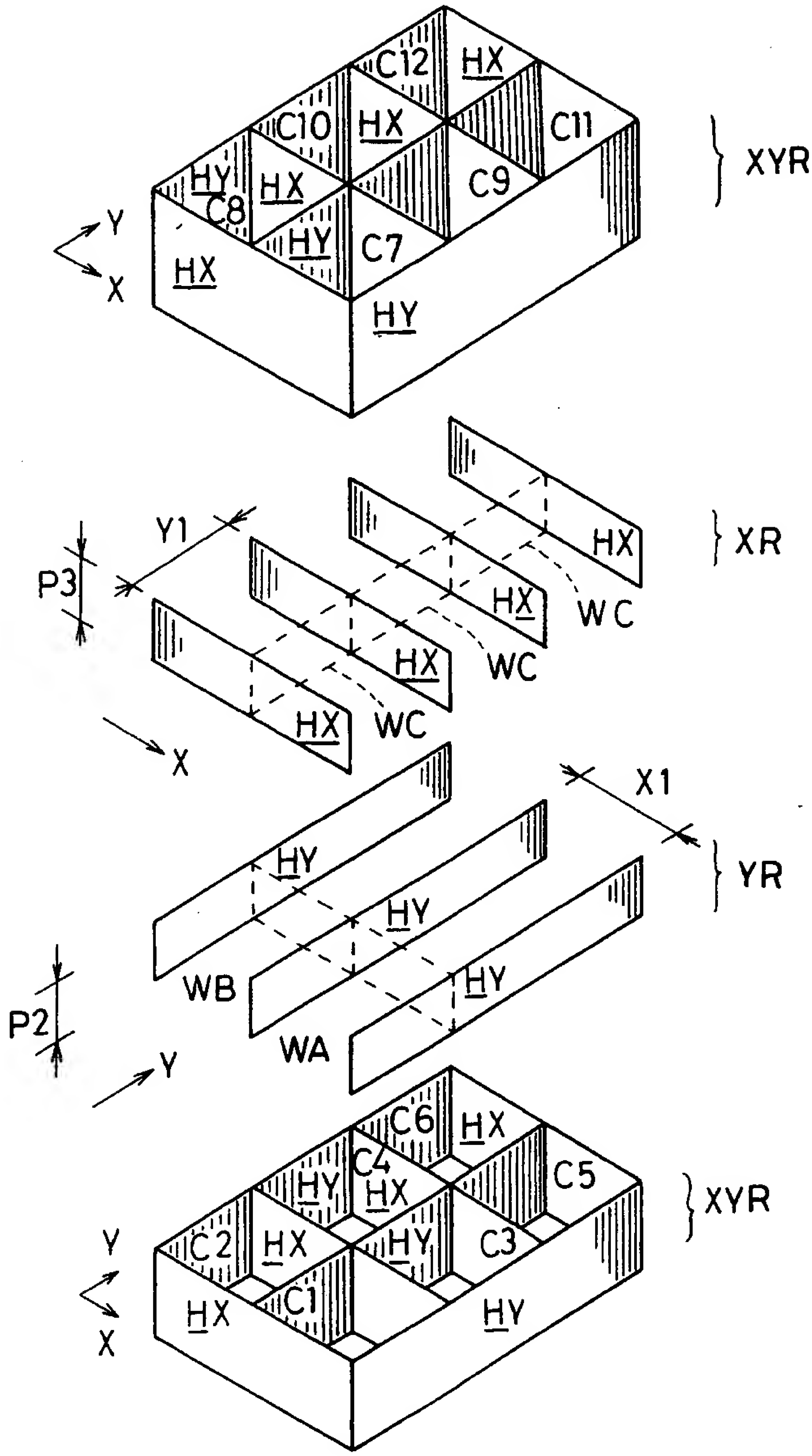
This construction provides a honeycomb structure of a cubic lattice having a remarkable strength and large communication ports in the X, Y and Z directions which assure more ready flow of unsolidified liquid in the superficial model.

Fourth Embodiment (honeycomb structure of the type in which through holes are formed in the ribs)

This embodiment uses through holes formed in the ribs, in place of elimination of any ribs as described in the first embodiment. FIG. 11 shows an example in which through holes W are formed in the vicinity of all corners of respective ribs HX, HY and HZ. Though three through holes are formed in each of the corners in FIG. 11, the least number of through holes each cell requires is two.

This construction assures communication among the cells through the through holes, permitting ready ejection of unsolidified liquid from the superficial model. The photo-solidified object according to the fourth embodiment is fabricated by a method in which the light exposure process for forming ribs is interrupted by a process of temporarily stopping light exposure.

As described above, the photo-solidified object provides a superficial model reinforced by an inner honeycomb structure having communication ports


C12
HX
C10
HX
C11
HY
HX
C9
C8
HY
C7
HX
HY
XYR
Y
X
Y1
P3
HX
XR
HX
WC
HX
WC
HX
WC
X
X1
HY
YR
HY
HY
WB
P2
WA
Y
C6
HX
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X

FIG.1

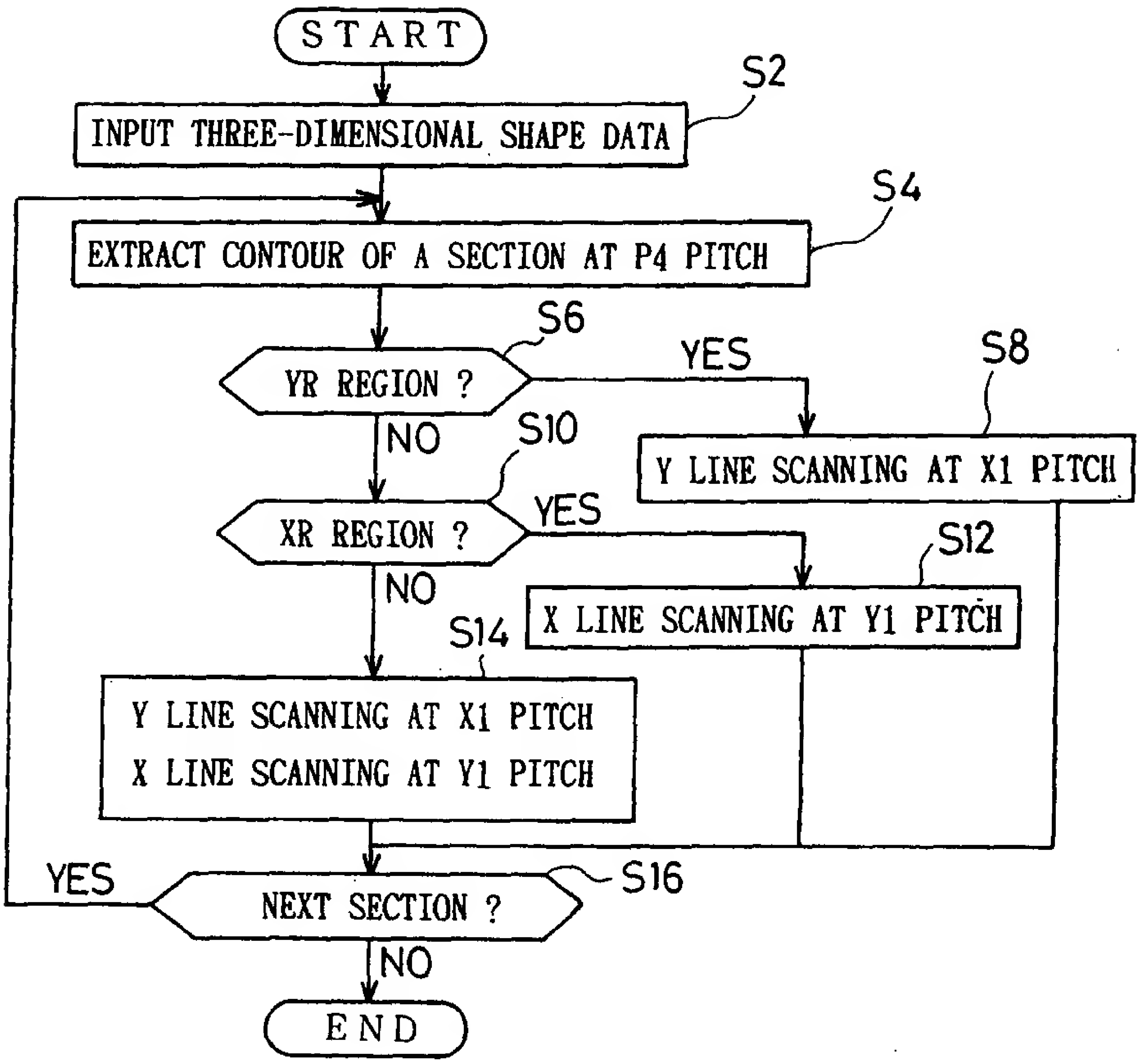
START
INPUT THREE-DIMENSIONAL SHAPE DATA
S2
EXTRACT CONTOUR OF A SECTION AT P4 PITCH
S4
YR REGION ?
S6
YES
NO
S8
Y LINE SCANNING AT X1 PITCH
XR REGION ?
S10
YES
NO
S12
X LINE SCANNING AT Y1 PITCH
S14
Y LINE SCANNING AT X1 PITCH
X LINE SCANNING AT Y1 PITCH
YES
NEXT SECTION ?
S16
NO
END

FIG. 3

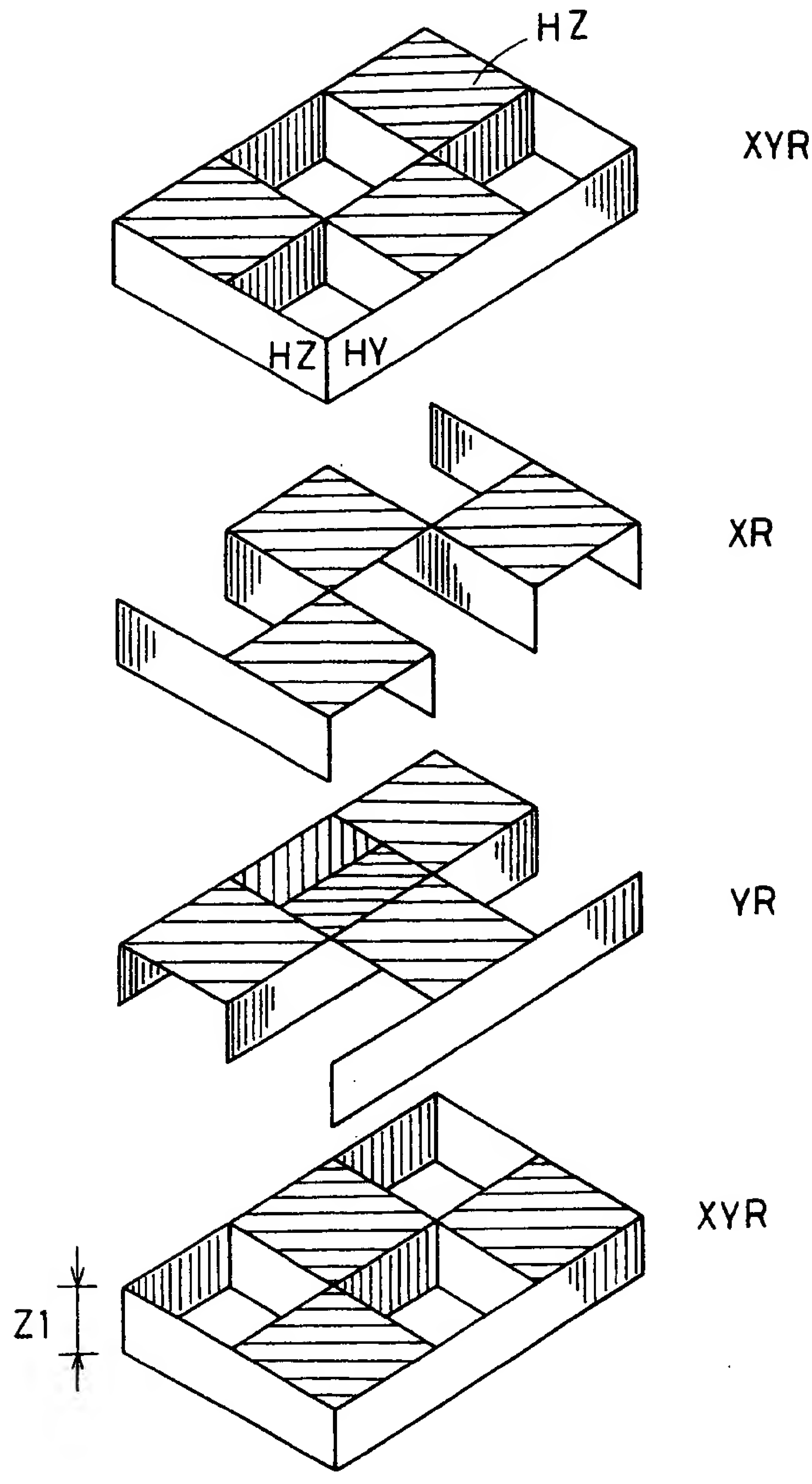

FIG. 5

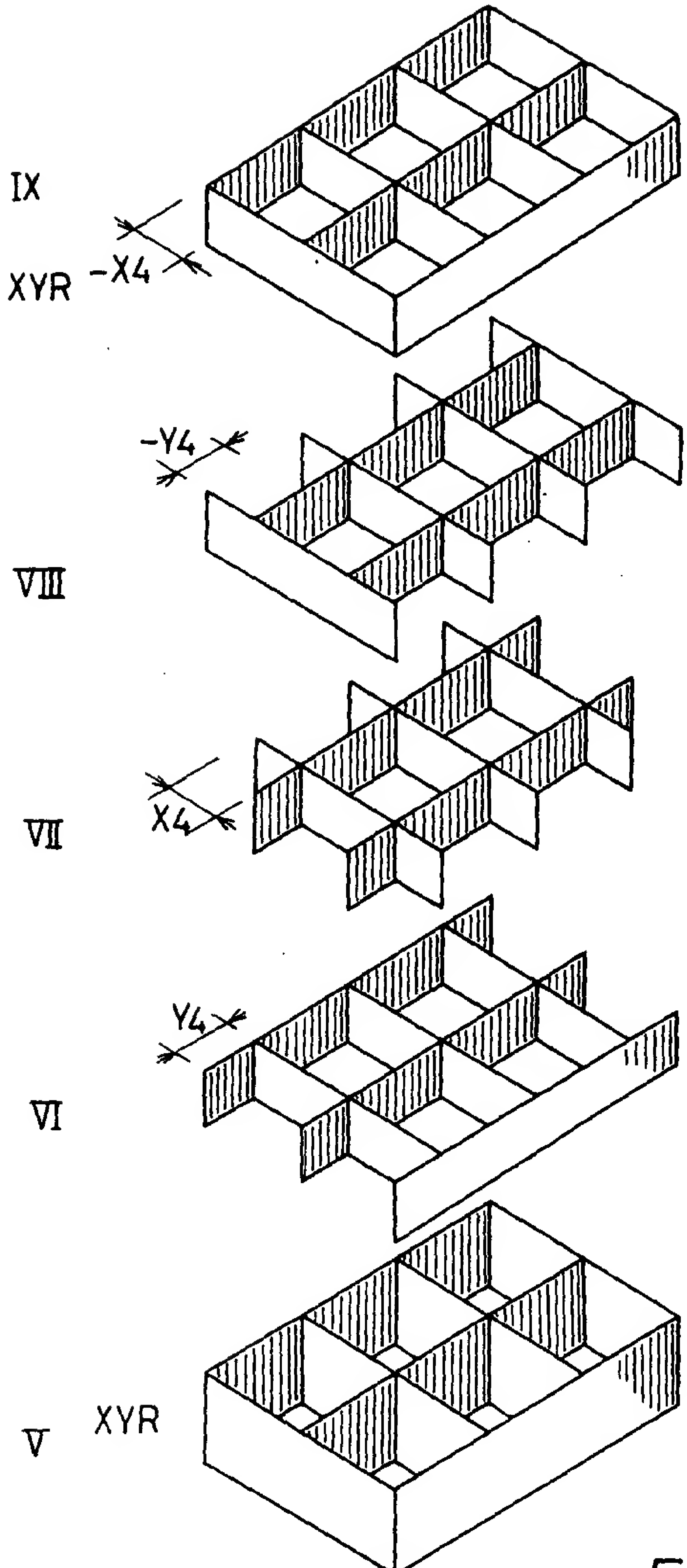

FIG.7

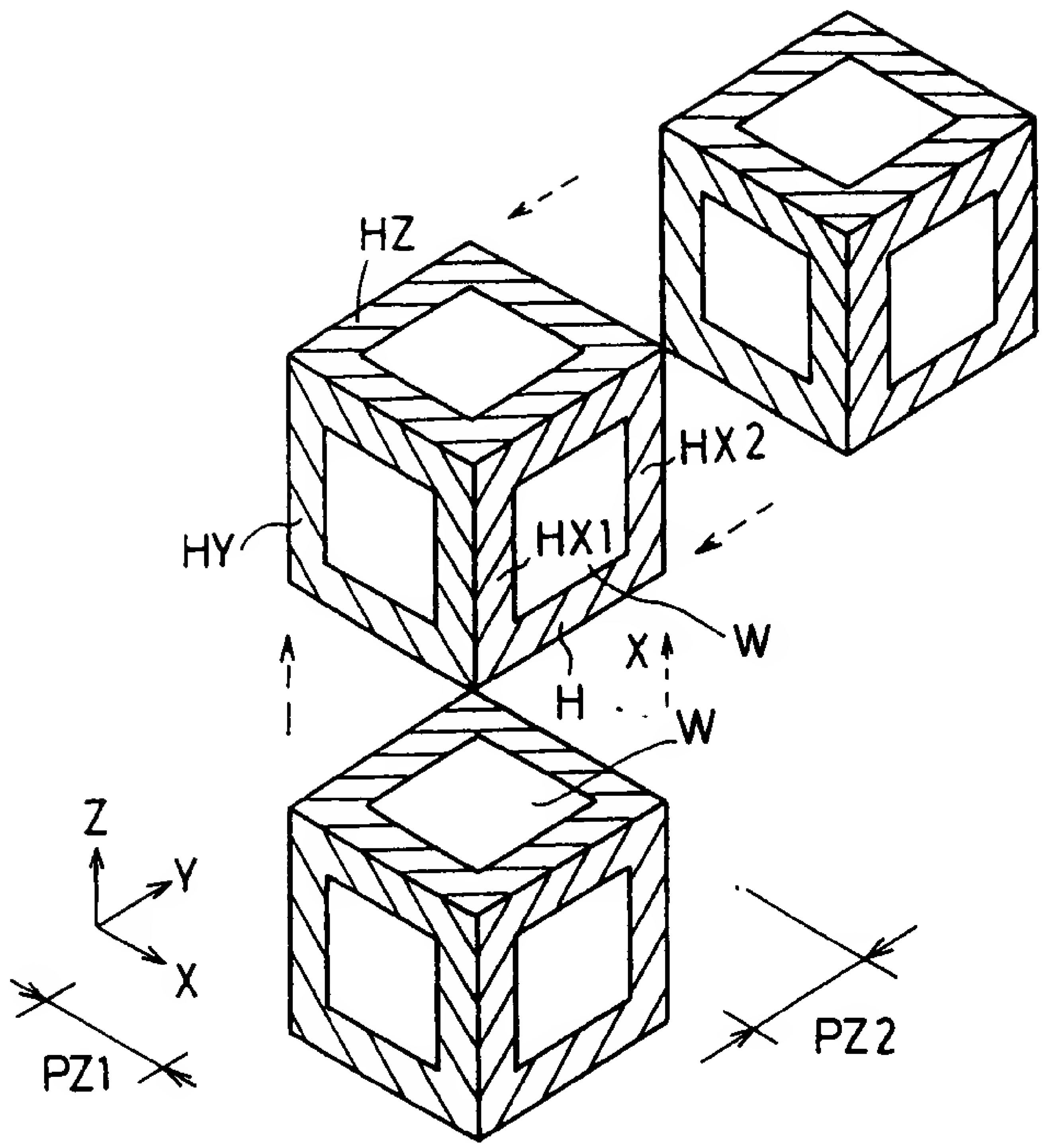

FIG. 9

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EUROPEAN SEARCH REPORT

Application Number
EP 93 30 7722

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X A	EP-A-0 484 183 (MITSUBISHI CORPORATION) * claim 1; figures 10C-10E * ---	6 1-5,7	B29C67/00
A	EP-A-0 250 121 (SCITEX CORPORATION LTD.) * claim 1; figure 1 * ---	1-7	
A	EP-A-0 322 257 (CUBITAL LTD.) * claim 1; figure 6 * -----	1-7	

TECHNICAL FIELDS SEARCHED (Int.Cl.5)

B29C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	9 November 1993	KIRSTEN, K

CATEGORY OF CITED DOCUMENTS

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